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Stochastic modeling of economic activity of costs on Innovation of the organization of the Republic of Tatarstan, in the formation of business processes

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ABSTRACT

The article is quite relevant, since in modern conditions the most important direction to increase the efficiency of the organization's activities is the reengineering of the enterprise's business processes and innovative processes. The article studies dependence - the cumulative level of innovative activity in the Republic of Tatarstan from several factors. There are determined which costs of innovation significantly affect on the formation of business processes.

It is built a linear model of dependence on the influencing factors. A regression model is constructed due to significant factors and a scattering diagram. The article presents the results of the study in the form of graphs of the correlation fields of the resultant characteristic Y and the factors X. Scattering diagrams are used. The quality of the constructed equation is estimated on the basis of the coefficients of determination and multiple correlation.

It is the approach of reengineering, which contributes to increase the effectiveness of the organization by adjusting its business processes and optimizing or replacing the business model used in it. It can help modern, innovative organizations.

Keywords: econometrics, scattering diagrams, correlation-regression analysis, innovations, innovation management, innovative economy, business process, factor analysis, business process modeling, Republic of Tatarstan.

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1. INTRODUCTION

It is studied the dependence of the cumulative level of innovation activity on several factors according to the data for 2016 which are presented in Table 1.

Table 1. Baseline data

Designation	The names of indicators:
Y	Aggregate level of innovation activity (%)
X_1	Product (%)
X_2	Process (%)
X_3	Organizational (%)
X_4	Marketing (%)
X_5	Environmental (%)

According to these data it is necessary to determine what expenses for innovation significantly affect the formation of the aggregate level of innovation activity and build a linear model of dependence on the influencing factors.

The types and kinds of economic activity were selected by groups, each group had a certain color in table 2:

1. High-tech - from 1 to 3 lines in Table 2 (red);
2. Medium-tech of high-level - from 4 to 6 lines in Table 2 (yellow);
3. Medium-tech of low-level - from 7 to 9 lines in Table 2 (green);
4. Low-tech - from 10 to 6 lines in the table 12 (blue).

Table 2. Data table

№	**Types and kinds of economic activity**	**Cumulative level of innovation activity (%) y**	**Innovation costs**				
			Technological (%) (x_1)	**Marketing (%) (x_2)**	**Organizational (%) (x_3)**	**Product (%) (x_4)**	**Process (%) (x_5)**
1	Manufacture of pharmaceutical products	28,0	97,0	2,6	0,4	61,0	36,0
2	Production of electronic components, equipment for	35,5	99,9	0,02	0,1	67,7	32,2

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	radio, television and communication						
3	Manufacture of medical devices; measuring instruments, control, test management; optical devices, photo and cinema equipment; watches	30,4	99,3	81,2	18,2	81,2	18,2
4	Chemical production	21,3	99,9	0,1	0,1	39,5	60,3
5	Manufacture of machinery and equipment	15,9	98,8	0,5	0,8	66,5	32,3
6	Manufacture of motor vehicles, trailers and semi-trailers	25,4	99,9	0,01	0,1	72,5	27,3
7	Manufacture of rubber and plastic products	12,4	99,1	0,8	0,1	57,6	41,4
8	Metallurgical production	21,7	99,5	0,1	0,3	21,1	78,5
9	Manufacture of finished metal products	11,7	99,9	0,05	0,02	76,9	23,0
10	Manufacture of food products, including beverages	12,3	90,0	9,0	1,1	59,3	30,6
11	Textile production	12,3	92,1	0,02	7,9	26,8	65,3
12	Manufacture of clothes; dressing and dyeing of fur	12,6	58,7	40,0	1,3	39,3	19,4

The values of the linear coefficients of pair correlation determine the tightness of the pairwise coupled variables used in the multiple regression equation.

Table 3. Correlation

	Y	***X1***	***X2***	***X3***	***X4***	***X5***
Y	1					

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X1	0,389265015	1				
X2	0,21881488	-0,33361435	1			
X3	0,229277879	0,035537632	0,814928	1		
X4	0,325381766	0,330895315	0,270586	0,186934	1	
X5	-0,093379269	0,271855845	-0,47729	-0,16697	-0,81816	1

Table 4. Conclusion on the nature of the relationship of variables

Associated variables	**Communication tightness**	**Communication direction**
Y and X_1	weak	straight line
Y and X_2	very weak	straight line
Y and X_3	very weak	straight line
Y and X_4	weak	straight line
Y and X_5	very weak	inverse
X_1 and X_2	weak	inverse
X_1 and X_3	very weak	straight line
X_1 and X_4	weak	straight line
X_1 and X_5	very weak	straight line
X_2 and X_3	high	straight line
X_2 and X_4	very weak	straight line
X_2 and X_5	weak	inverse
X_3 and X_4	very weak	straight line
X_3 and X_5	very weak	inverse
X_4 and X_5	high	reverse

2. MATERIALS AND METHODS

Analysis of the matrix of coefficients of pair correlation shows that the factors X_2 and X_3 are closely related ($r_{x_2x_3} = 0.815$), as well as factors X_4 and X_5 ($r_{x_4x_5} = -0.818$), which indicates the presence of collinearity. From these variables we leave everything.

In this example, n = 9, m = 6, after excluding insignificant factors n = 9, k = 2.

We give graphs of correlation fields of the resultant sign of Y and factors X. For this we use scattering diagrams [Antropova T.G., Ishmuradova I.I., Minsabirova V.N., Gazizova F.S. (2015).].

In the scattering diagram the relationship between two numerical variables is represented graphically. One variable (independent variable X) defines a horizontal axis and the other (dependent variable Y) defines a vertical axis. The values of two variables on the same line in the data table give points on the diagram [Levina E.Y., Pyrkova G.K., Zakirova C.H., Semikova O.R., Nabiullina K.R., Ishmuradova I.I. (2015).].

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Diagrams of scattering are the areas used to construct data points on the horizontal and vertical axis showing how much one variable depends on the other.

The relationship between two variables is called their correlation. If the markers are close to creating a straight line in a point line, then two variables have high correlation. If the markers are evenly distributed into a point marker the correlation is low or zero [Shinkevich M.V., Shinkevich A.I., Chudnovskiy A.D., Lushchik I.V., Ishmuradova I.I. (2015).].

Each unit contributes to one point in the scattering diagram on which the points are delayed but not joined. The resulting picture indicates the type and strength of the relationship between these two variables.

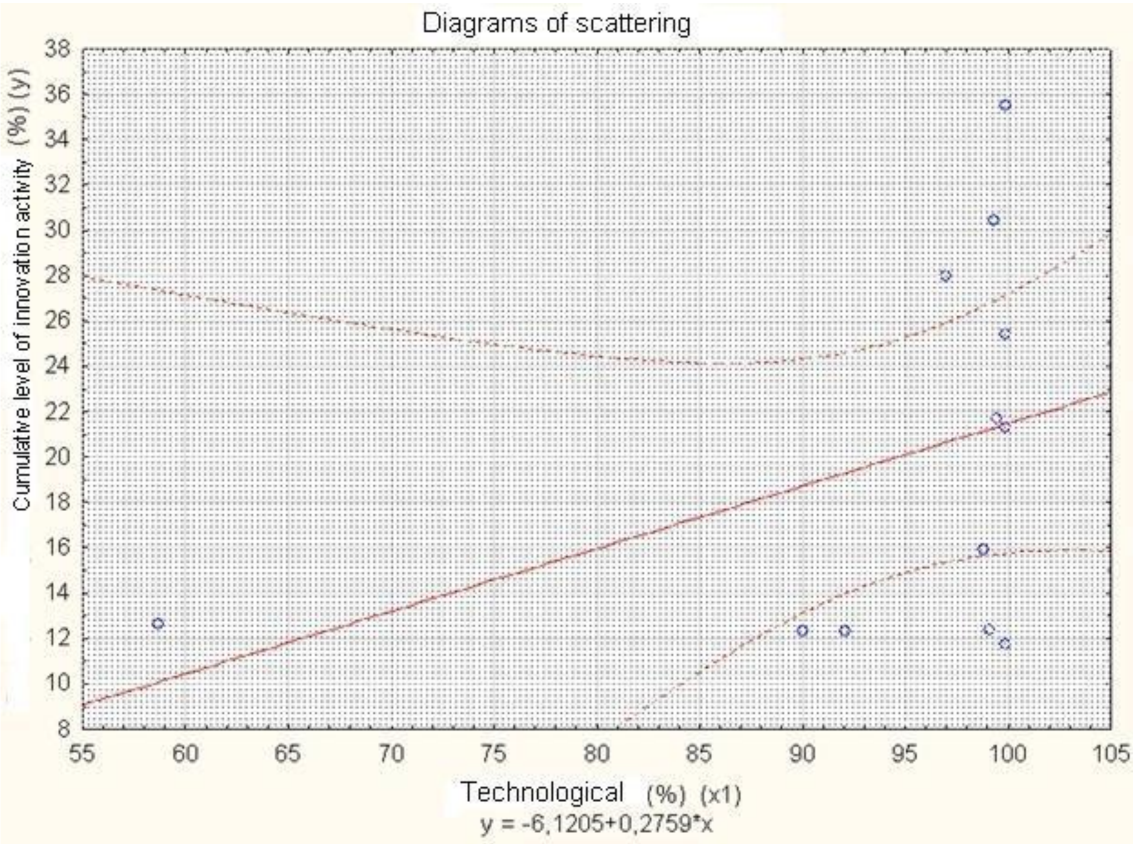

Figure 1. Diagrams of scattering Technological

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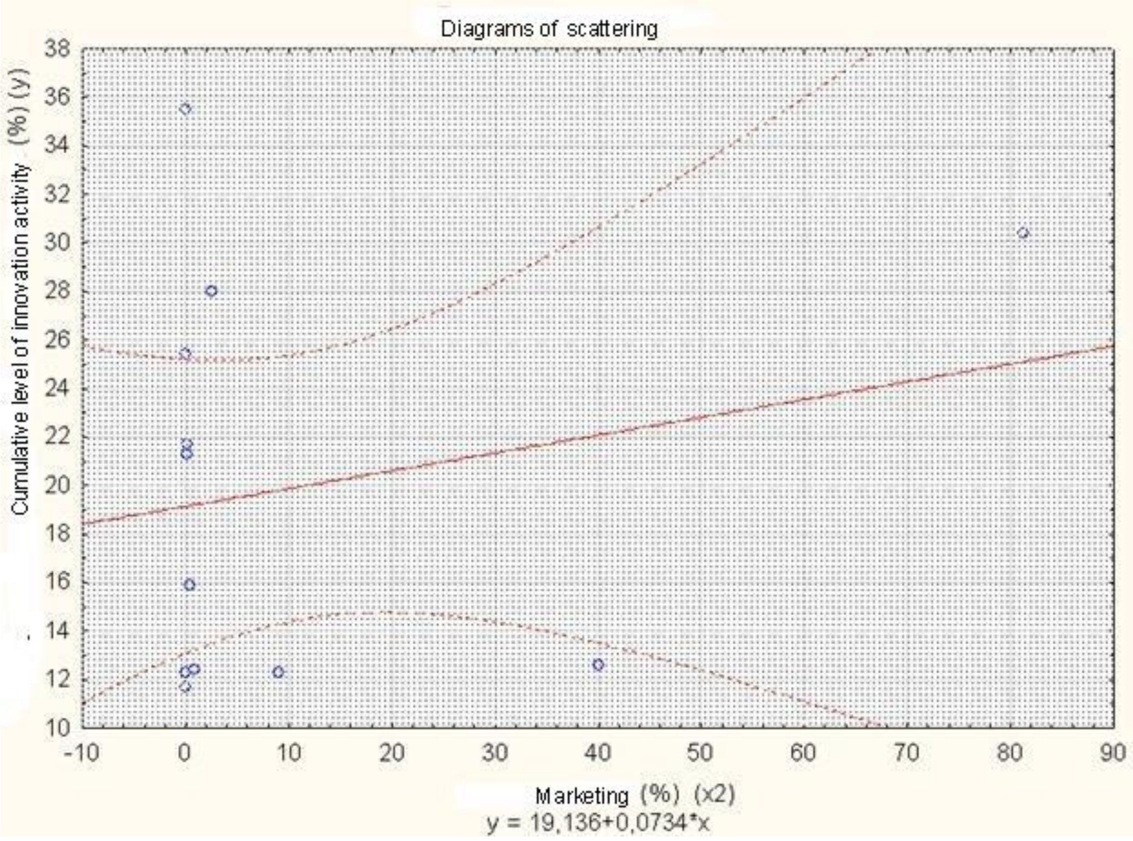

Figure 2. Diagrams of scattering marketing

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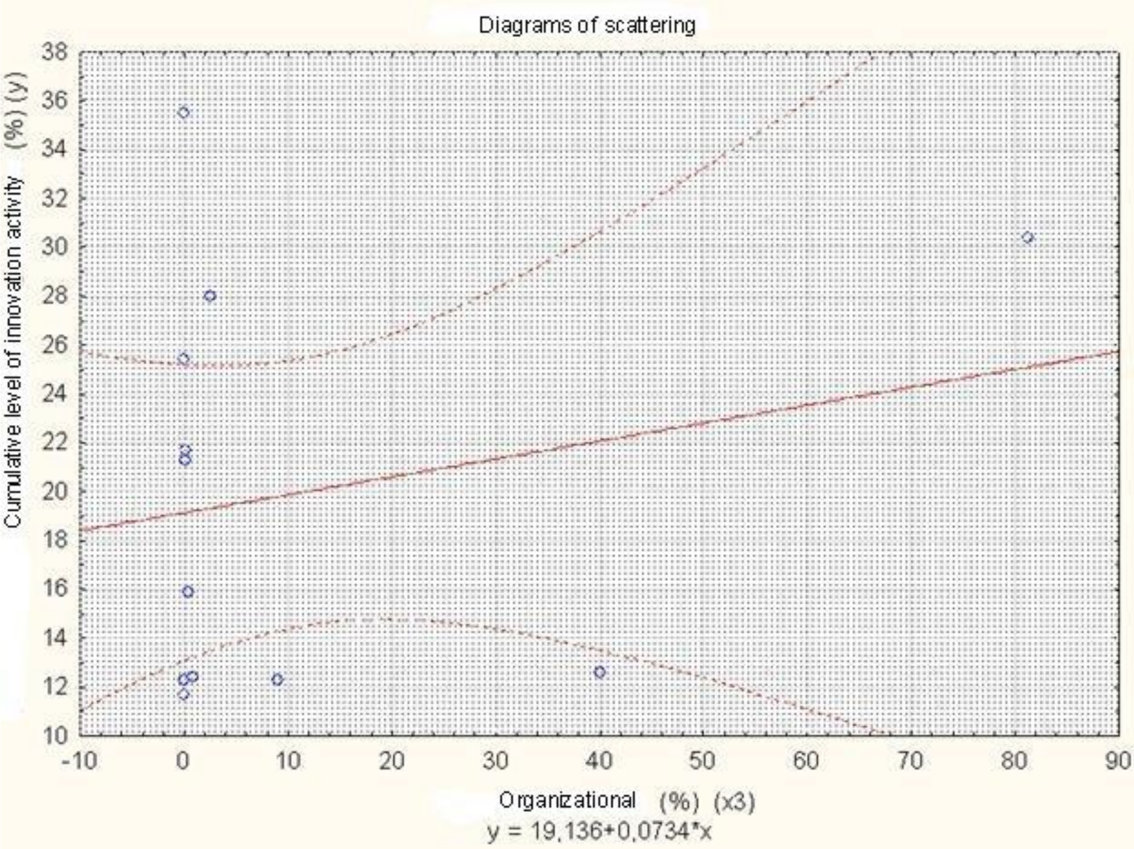

Figure 3. Diagrams of scattering organizational

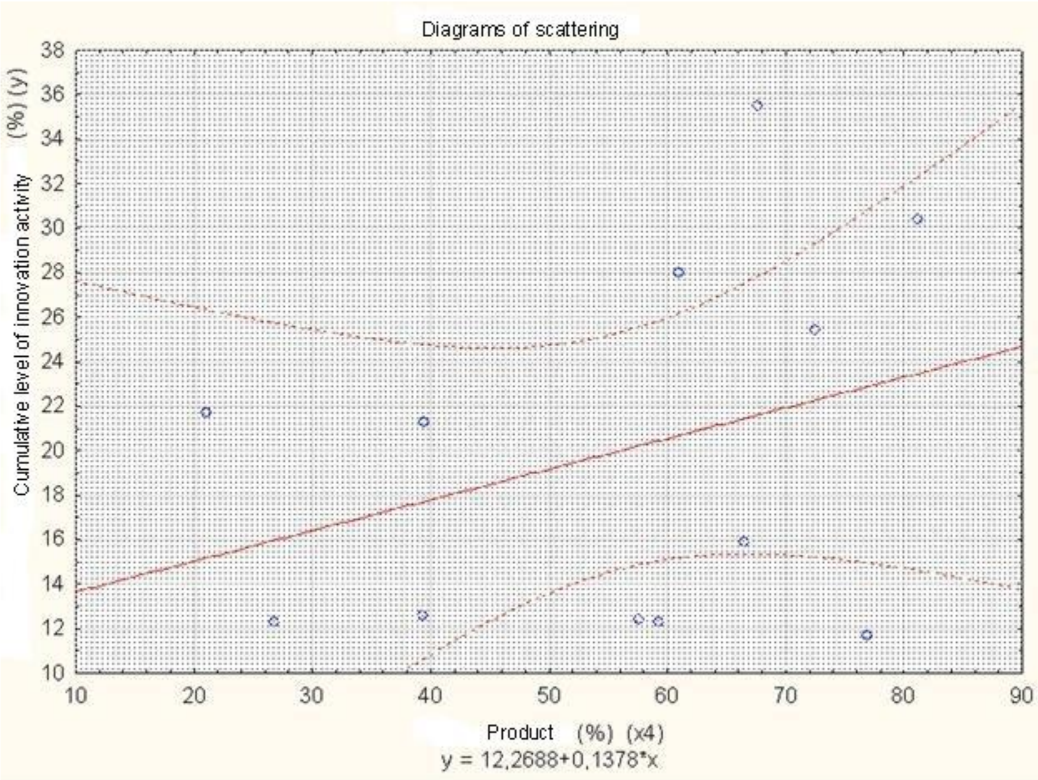

Figure 4. Diagrams of scattering product

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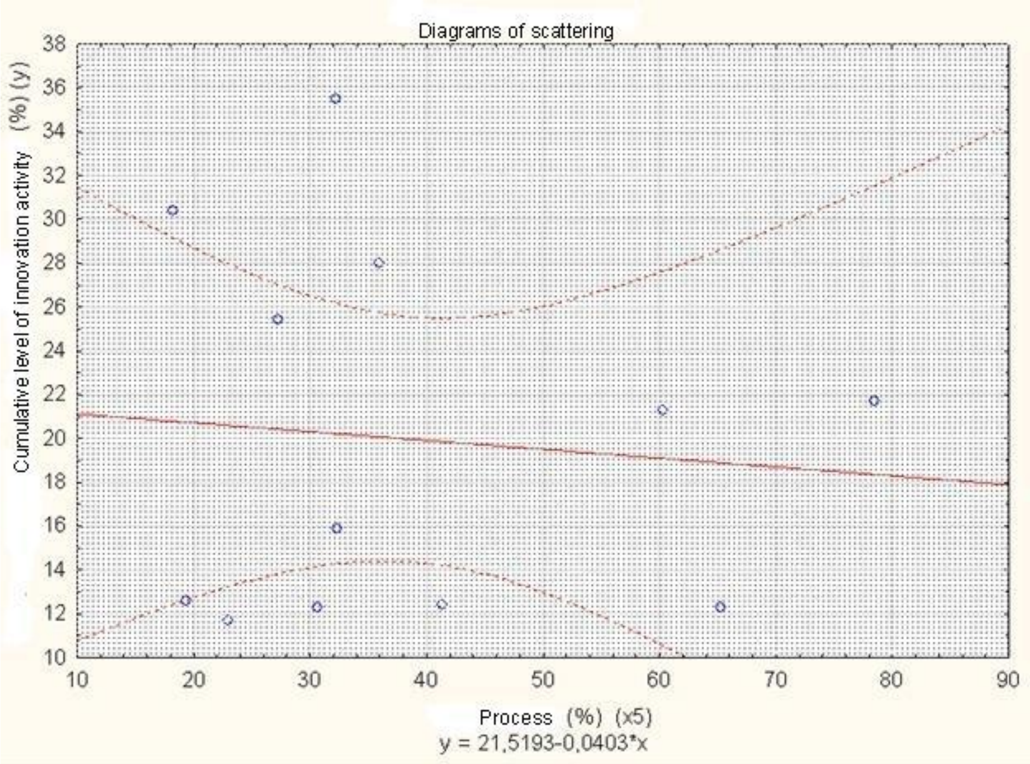

Figure 5. Diagrams of scattering process

3. RESULTS AND DISCUSSIONS

After a visual analysis of the empirical data. Graphically we determine the linear regression function. To do this a line has been built on the diagram - a straight line of regression. The accumulation of points in the diagrams of all figures shows that in the costs of product innovation (x_1) and the costs of organizational innovation (x_4) there is a clearly pronounced tendency to increase the aggregate level of innovation activity (y). This trend has a clearly linear character so you can try to approximate the dependence considered by the linear regression function. Of course this trend exists only on the average, it is disturbed by deviations of individual points [Shinkevich A.I., Galimulina F.F., Moiseyev V.O., Avilova V.V., Kuramshina K.S., Ishmuradova I.I. (2016).]. Deviations from a straight line are explained by the influence of other unaccounted or accidental factors to each fixed value of costs for product innovations (x_1) and costs for organizational innovation (x_4) there corresponds a number of values of the aggregate level of innovation activity (y).

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CONCLUSION OF THE RESULTS

Regression Statistics	
Multiple R	0,616867
R-Square	0,380525
Standardized R-Square	-0,1357
Standard Mistake	8,875202
Observations	12

ANALYSIS OF VARIANCE

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	290,313862	58,06277239	7,737125165	0,622382988
Remainder	6	472,6153047	78,76921745		
Total	11	762,9291667			

	Coefficient	*Standard mistake*	*t-statistics*	*P-Meaning*	*Lower 95%*	*Upper 95%*	*Lower 95%*	*Upper 95%*
Intersection-Y	-24,4419	31,1458572	-0,784754765	0,462447599	-100,6530269	51,76930725	-100,6530269	51,76930725
Variable X 2	-28,1619	47,25317642	1,595978296	0,57297013	-143,7862249	87,46248981	-143,7862249	87,46248981
Variable X 2	0,248954	0,302977223	0,821690893	0,442671871	-0,492404933	0,990312183	-0,492404933	0,990312183
Variable X 3	-0,82264	1,151874138	1,714171866	0,5019457	-3,641170584	1,995898377	-3,641170584	1,995898377
Varable X 4	28,63517	47,22159893	0,606399845	0,566469656	-86,91191977	144,1822603	-86,91191977	144,1822603
Variable X 5	28,62079	47,15244784	0,606984256	0,566106457	-86,75708995	143,9986769	-86,75708995	143,9986769

Figure 6 - Regression

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4. SUMMARY

The equation of multiple regression in linear form with a full set of factors has the form:

$y = -24{,}441 - 28{,}161x_1 + 0{,}248x_2 - 0{,}822x_3 + 28{,}635x_4 + 28{,}620x_5$

1. Let us to estimate the significance of the equation of the regression obtained using the Fisher test.

The F value of the Fisher test can be found in Table. the Excel protocol (Figure 2) F_{cal} = 7,737, F_{tab} = 3,11 (with a confidence level of 0.95, with v1 = k = 5 and v2 = n-k 1 = 12 - 5 - 1 = 6).

As far as $|F_{cal}| > F_{tab}$ the regression equation should be considered adequate and the hypothesis H0 on the random nature of the statistical relationship is rejected. The available statistical data indicate that in 95% of cases the connection is due to the influence of regression factors and the other factors are not included in it are statistically insignificant [Ishmuradova I.I., Ishmuradova A.M,2015].

The significance of the coefficients of the regression equation is estimated using the t Student's test, the calculated values of which are given in the fourth column of the Excel protocol (Fig. 6). The table value of the t criterion at 5% significance level and degrees of freedom (12-5-1 = 6) is 2. Since $|t_{cal}| > t_{tab}$, the coefficient for X_1 and X_3 is significant. Consequently factors are also significant.

2. In order to determine whether the cost factors are significant for the cumulative level of innovation activity it is necessary to evaluate the significance of the coefficient of the equation for X_1 and X_3 using the t-criteria of the Student's test (Figure 2). In the first case t_{cal} = 1,595 and in the second t_{cal}= 1,714 and the tabular value t_{tab} = 1.3562. Since $|t_{cal}| > t$ tab, the coefficients X_1 and X_3 are significant, therefore, factors are significant, that is, they should not be excluded from the model.

3. We will construct a model of the average expected innovation activity due to significant factors. Since the factors X_1 and X_3 are closely related to each other and factors X_1 and X_3 are also closely related, from these variables one can leave in the model factor X1 - the product costs for innovations, products, works, services. In this example, n = 12, m = 5, after excluding the insignificant factors n = 12, k = 2. Let us to use the Regression tool.

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CONCLUSION OF THE RESULTS

Regression Statistics	
Множественный R	0,839265015
R-квадрат	0,861527252
Нормированный R-квадрат	0,066679977
Стандартная ошибка	8,045648555
Наблюдения	12

ANALYSIS OF VARIANCE

	df	*SS*	*MS*	*F*	*Significance F*
Регрессия	1	115,60456	115,60456	1,785882366	0,741039395
Остаток	10	647,3246067	64,73246067		
Итого	11	762,9291667			

	Coefficient	*Standard mistake*	*t-statistics*	*P-Meaning*	*Lower 95%*	*Upper 95%*	*Lower 95%*	*Upper 95%*
Intersection-Y	6,120545811	19,6524546	-0,311439255	0,761862473	-49,90894343	37,66785181	-49,90894343	37,66785181
Variable X1	0,275942642	0,206486847	1,336369098	0,211039395	-0,184138725	0,736024008	-0,184138725	0,736024008

TOTAL OF THE REMAINDER

Observation	*Predicted Y*	*Remainders*	*Standard remainders*
1	20,64589042	7,354109585	0,95866171
2	21,44612408	14,05387592	1,832025016
3	21,28055849	9,119441509	1,188785575
4	21,44612408	-0,146124075	-0,019048337
5	21,14258717	-5,24258717	-0,683409395
6	21,44612408	3,953875925	0,515416504
7	21,22536996	-8,825369962	-1,150451209
8	21,33574702	0,364252981	0,047483027
9	21,44612408	-9,746124075	-1,270478209
10	18,71429192	-6,414291925	-0,836149638
11	19,29377147	-6,993771472	-0,911689014
12	10,07728725	2,522712755	0,328853969

TOTAL OF PROBABILITY

Percenthile	*Y*
4,166666667	11,7
12,5	12,3
20,83333333	12,3
29,16666667	12,4
37,5	12,6
45,83333333	15,9
54,16666667	21,3
62,5	21,7
70,83333333	25,4
79,16666667	28
87,5	30,4
95,83333333	35,5

Figure 7 - Regression with respect to variable X_1

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y = 6,120 + 0,275x_1 - regression model due to significant factors. Economic interpretation of the model coefficient: an increase in technological innovation costs by 0.275%, innovation activity is increasing by 6.120%.

We estimate the quality of the constructed equation on the basis of the coefficients of determination and multiple correlation which can be found in the [Ishmuradova I.I., Sibaeva G.R.2016] Regression statistics table (Fig. 7).

Coefficient of determination R_2 = 0.861 - it shows the variation of the effective trait under the influence of the studied factor. Consequently, about 86% of the variation of the dependent variable is taken into account in the model and is due to the influence of the included factor.

Coefficient of multiple correlation R = 0.893 - it shows the tightness of the relationship of the dependent variable with the factor included in the model. [Ishmuradova I.I., Shinkevich A.I.2016]. In this case the connection is strong.

Elasticity coefficient $Эл._{yx1}=b_1*(x_1/y)$

El = 0.275 * (99 / 12.6) = 0.21 - when the factor X1 changes by 1%, the dependent variable Y will change by 21%, that is, it will increase by 21%.

Beta is the coefficient: $\beta_j = a_j * (S_{xj} / S_{(y)})$, S_{xj} is the standard deviation. β_1 = 0.275 * (0.88 / 7.97) = 0.30.

Beta-coefficient shows the part of the value of the standard deviation S_y the dependent variable Y changes with the change of the independent variable X_1 by its root-mean-square deviation with the value of the remaining independent variables fixed at a constant level [Ishmuradova I.I., Sibaeva G.R2015.]. This means that with an increase in the cost of technological innovation in our example by 69% the cumulative level of innovation activity will increase by 69%. (0.011 * 63.58 = 0.69)

Delta coefficient: $\Delta_j = r_{(y, xj)} * \beta_j / R ^ 2$, $r_{(y, xj)}$ is the coefficient of pair correlation between the factor and the dependent variable, R ^ 2 is the coefficient of determination. Δ = 0,001 * (0,001 / 0,08) = 0,0000125 (values $r_{(y, xj)}$ and R ^ 2 are taken from the Excel report in Figures 6 and 7). Consequently, the share of influence of factor X_1 in the combined effect of all factors is 0.00002.

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5. CONCLUSION

Based on the analysis the following conclusions can be drawn:

Process costs for innovation and marketing costs X_2 and X_3 are closely related (r_{x2x3} = 0.815) as well as the organizational and environmental costs of innovation X_4 and X_5 (r_{x4x5} = -0.818) which indicates collinearity.

The multiple regression equation in linear form with a full set of factors will have the form:

y = -24,441- 28,161x1 + 0,248x2 - 0,822x3 + 28,635x4 + 28,620x5

Since $|F_{cal}|$ > Fable the regression equation should be considered adequate and the hypothesis H_0 on the random nature of the statistical relationship is rejected. The available statistical data indicate that in 95% of cases the connection is due to the influence of regression factors and the other factors not included in it are statistically insignificant.

The significance of the coefficients of the regression equation is estimated using the t-crireria of Student's test the calculated values of which are given in the fourth column of the Excel protocol (Fig. 7) [10]. The table value of the t -criteria at 5% significance level and degrees of freedom (12-5-1 = 6) is 2. Since $|t_{cal}|$ > t_{tab}, the coefficient for X_1 and X_3 is significant. Consequently, factors are also significant.

As a result of estimating the coefficients, the product costs of innovation (X_1) and the organizational costs of innovation (X_3) using Student's t-criteria test found that it is not necessary to exclude them from the model since in the first case t_{cal} = 1,595, and in the second t tab= 1,714 . A tabular value: t_{tab} = 1.3562. From the condition $|t_{cal}|$ > t tab it follows that they are significant.

Process costs of innovation due to significant factors will have the form: y = 6,120 + 0,275x1.

Economic interpretation of the model coefficient: an increase in the process costs of innovation by 0.275%, innovation activity is increasing by 6.120%.

Coefficient of determination R_2 = 0.861 shows the variation of the effective trait under the influence of the studied factor. Consequently, about 86% of the variation of the dependent variable is taken into account in the model and is due to the influence of the included factor.

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Coefficient of multiple correlation R = 0.839 shows the tightness of the relationship of the dependent variable with the factor included in the model. In this case the connection is strong.

Coefficient of elasticity E = 0.74 - when the factor X1 changes by 1% the dependent variable Y will change by 21%, that is, it will increase by 74%.

Beta is the coefficient: β_1 = 0.30. It shows which part of the magnitude of the standard deviation S_y the dependent variable Y changes with the variation of the independent variable X_1 by its root-mean-square deviation with the value of the remaining independent variables fixed at a constant level. This means that the cumulative level of innovation activity will increase by 69%.

Delta - coefficient: Δ = 0,0000125. Consequently, the share of influence of factor X_1 in the combined effect of all factors is 0.00001.

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